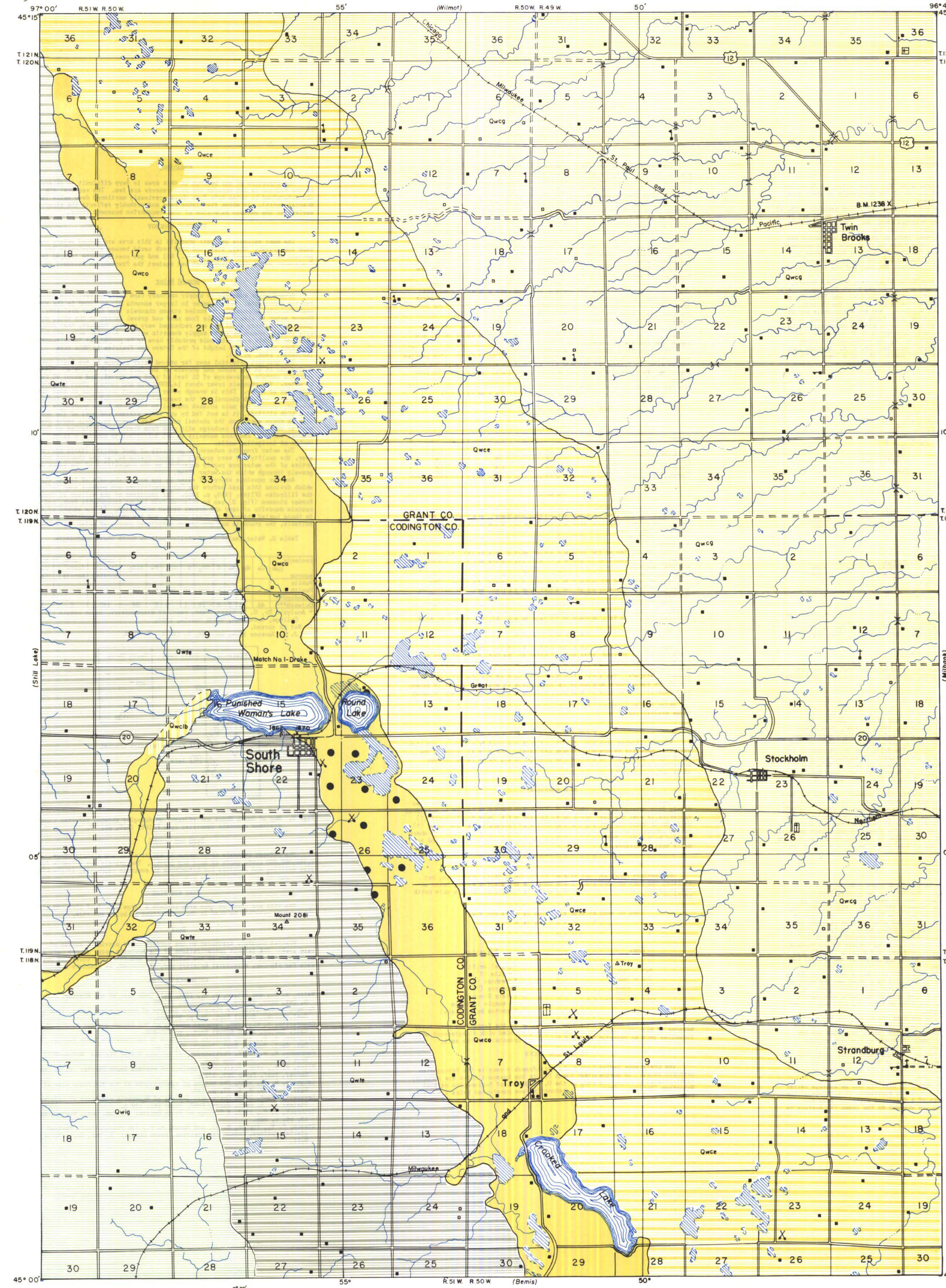
SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

GEOLOGY of the SOUTH SHORE QUADRANGLE SOUTH DAKOTA



EXPLANATION

QUATERNARY — PLEISTOCENE — WISCONSIN

Qwclb — Cary Lake Beds
(Parallel-bedded deposits of silt, sand, and clay; evident by strand lines above shores of some lakes and in some cases rimmed with boulders)

Qwco — Cary Outwash
(Stratified meltwater deposits of sand, gravel, and silt; collapsed areas shown by dotted pattern)

Qwce — Cary End Moraine
(Ridge-like accumulations of till; characterized by rough topography, undrained depressions, and boulder-strewn surface)

Qwcg — Cary Ground Moraine
(Relatively flat accumulations of till; characterized by swell and swale topography, undrained depressions, and boulder-strewn surface)

Qwte — Tazewell (?) (Bemis) End Moraine
(Ridge-like accumulations of till; characterized by smooth slopes, and very few undrained depressions or boulder-strewn areas)

Qwig — Iowan (?) Ground Moraine
(Plateau-like accumulations of till; characterized by well developed drainage, smooth slopes, very few boulders, and no undrained depressions)

Contact
(dashed where approximately located)

Gravel Pit

x BM 1366
Bench Mark
(monument showing exact altitude above sea level)

Mount
Triangulation Station
(monument marking exact geographic location)

House, school, and church

Cemetery

Match No. 1 - Drake
Oil Test Boring

Geology by Merlin J. Tipton 1957
Assisted by R. C. Wilson
Vertical and horizontal controls surveyed from triangulation and level lines of Federal surveys.
Drafted by J. H. Hoff, 1958

TRUE NORTH — MAGNETIC NORTH — 9° 30'
APPROXIMATE MEAN DECLINATION 1958

Scale 1:62500
1 1/2 0 1 2 3 4 Miles

Vermillion, South Dakota
1958

Quadrangle Location

South Shore Quadrangle

INTRODUCTION

The South Shore quadrangle includes about 214 square miles, in Grant and Codington Counties. The southwestern corner of the quadrangle is about nine miles northeast of the city of Watertown.

The area is in the Western Lake and Dissected Till Plain sections (fig. 1) of the Central Lowlands physiographic province (Fenneman, 1938, map), and is on the eastern side of the Coteau des Prairies (Rothrock, 1943, map), a relatively high plateau-like feature of eastern South Dakota, southwestern Minnesota, and northwestern Iowa (Carman, 1915, p. 243). The quadrangle has no rivers or large streams; however, innumerable small streams drain eastward off the Coteau. The largest lakes are Punished Woman's and Round lakes in the central part of the quadrangle and Crooked Lake in the southern part. The maximum relief of the area is approximately 800 feet and the local relief ranges up to 100 feet.

Four small towns (South Shore, Stockholm, Strandburg, and Twin Brooks, each with populations less than 300) are present in the South Shore quadrangle. U. S. Highway 12 crosses the northeastern part of the area, and State Route 20 crosses the center. Adequate rail service is provided by the Chicago, Milwaukee, St. Paul and Pacific, Great Northern, and the Minneapolis and St. Louis railroads. Gravel roads and improved dirt roads make almost any part of the quadrangle easily accessible by car. The climate is characterized by a wide temperature range and an average precipitation of 20 inches per year.

The geology was mapped on air photos during the summer of 1957 under the supervision of Dr. A. F. Agnew, State Geologist. Dr. M. M. Leighton lent invaluable aid in differentiating the drift sheets, through a two-day field conference.

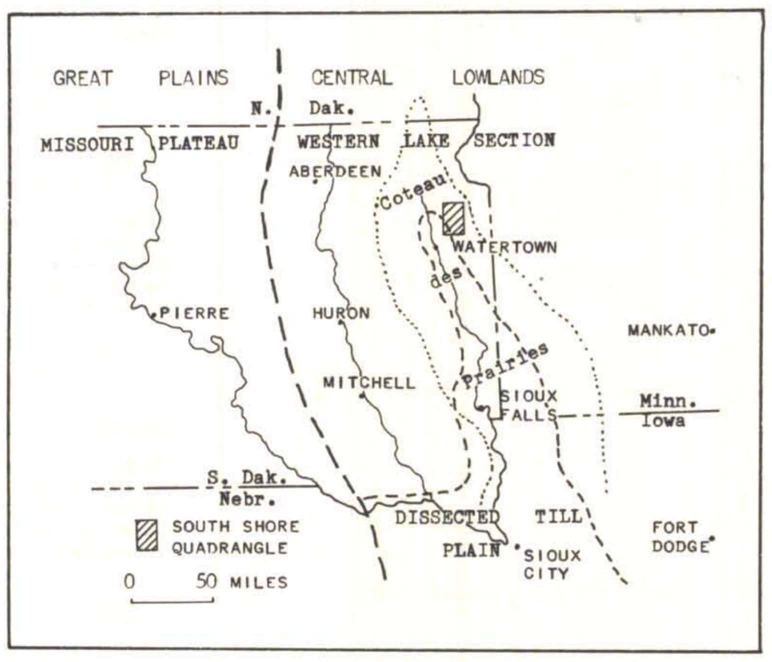


Fig. 1. Map showing physical divisions of eastern South Dakota and adjoining area (after Rothrock, 1943; Fenneman, 1938; and Carman, 1915).

SURFICIAL DEPOSITS

The quadrangle is covered by unconsolidated material that can be separated into three main groups: (1) glacial deposits, (2) stream and lake deposits, and (3) wind deposits.

Glacial Deposits

The first ice sheet to cover eastern South Dakota was the Nebraskan, and it was followed by the Kansan, Illinoian, and Wisconsin sheets. The Wisconsin had four separate advances (Leighton, 1933, p. 168), from oldest to youngest, the Iowan, Tazewell, Cary, and Mankato. The ice sheets deposited drift consisting of clays, silts, sands, gravels, and boulders reworked from bedrock and older surficial deposits. The drift lies on the bedrock and, in the north-central part of the Coteau des Prairies, is approximately 500 feet thick, as shown by the U. S. Bureau of Reclamation well at Watertown (Erickson, 1955, p. 24), the Oil Ventures #1 Naessig oil test near Webster (Bolin and Petsch, 1954, p. 17), and the Match #1 Drake oil test at South Shore (see Subsurface Sedimentary Rocks).

The drift is divisible into three groups: till, outwash, and glacial lake deposits. Till is the most abundant, and consists of an unsorted and unstratified mixture of material that ranges in size from boulders to clay. The till was produced through abrasion by the ice sheet against the land surface. Outwash consists of stratified sand, gravel, and silt reworked from the drift and deposited by the meltwater streams of the ice sheet. Glacial lake deposits, the least-abundant material in the drift, consist of parallel-bedded silt, sand and clay, deposited from streams as the entered ponded water held behind temporary glacial dams.

Till

The till exposed at the surface in the South Shore quadrangle is of Iowan (?), Tazewell (?), and Cary age. The till in the northeastern two-thirds of the quadrangle is Cary in age, that in the southwestern part is Iowan (?) in age and the remainder is Tazewell (?) in age. Flint (1955, pl. 1) called the Iowan (?) till Tazewell in age, the Tazewell (?) till Cary in age, and the Cary till Mankato in age. This and other related problems will be discussed in a later publication (Steece, Tipton, Agnew, In Preparation).

Till surfaces can be divided topographically into ground moraine and end moraine. Ground moraine is till that was carried forward in and beneath the ice and was deposited from its under surface. End moraine is till that was formed into ridge-like accumulations along the margin of the glacier by its conveyor-belt and snowplow action.

In the South Shore quadrangle the Iowan (?) till has a gently undulating ground moraine surface, and the Tazewell (?) till is a prominent end moraine. The Tazewell (?) moraine was given the name "Bemis" by Leverett (1932, p. 57). The Altamont moraine (Chamberlin, 1883) lies east of the Bemis moraine and is also a high prominent end moraine, but Cary in age. The till east of the Altamont moraine is Cary ground moraine.

The Iowan (?) ice sheet apparently overrode the Coteau des Prairies, as Iowan (?) till is found on top of the Coteau; however, the Tazewell (?) and Cary ice sheets were split by the Coteau into two lobes, the James and Des Moines. The James lobe followed the James River valley down the western side of the Coteau, and the Des Moines lobe followed the Des Moines River valley down the eastern side of the Coteau. In the South Shore quadrangle the Bemis moraine marks the westernmost advance of the Tazewell (?) till from the Des Moines lobe, and the Altamont moraine marks the westernmost advance of the Cary till from the Des Moines lobe.

The Iowan (?) ground moraine is very well drained, has an average relief of 15-20 feet and smooth slopes, and a striking accordance in altitude of the interfluves which gives the appearance of a dissected plateau. Very few boulders and no undrained depressions are present on the Iowan (?) surface in this area.

The topography of the Bemis (Tazewell ?) end moraine in this area is similar to that of the Iowan (?) ground moraine in that it is well drained, has smooth slopes, and very few undrained depressions. This similarity makes it difficult to distinguish the two moraines on air photos. However, in field mapping the two moraines are readily differentiated, as the Tazewell (?) till is marked by a high ridge-like end moraine and the Iowan (?) till surface is relatively flat. The Tazewell (?) end moraine has as average relief of 25-30 feet, and the local relief (the difference in height between knolls and depressions) ranges up to 60 feet. In general, the moraine has very few boulders on its surface but small concentrations of boulders occur locally.

The Altamont (Cary) end moraine is easily distinguished from the Iowan (?) and Tazewell (?) moraines in that it is very poorly drained, has steep and abrupt slopes, many undrained depressions, and is liberally strewn with boulders. The Altamont moraine has an average relief of 15-20 feet and the local relief ranges up to 50 feet.

In general, the topography of the Cary moraine is rough and rugged and the topography of the Iowan (?) moraine is smooth and undulating, whereas the topography of the Tazewell (?) moraine seems to be intermediate. These three types of topography may reflect different characteristics of the individual ice sheets, but more probably are the result of the difference in age and thus length of time of post-depositional erosion.

These three tills cannot be differentiated in this area by lithology; all are gray to buff, unleached, locally oxidized in their upper parts, and range from friable to compact.

An unsuccessful attempt was made to differentiate the Cary, Tazewell (?) and Iowan (?) tills by using composition of the four to eight mm. size pebbles (table 1.). In Table 1 an apparent differentiation of the tills in the local rocks and the limestone and dolomite is only apparent, as many samples overlapped. This overlapping and similarity in composition may be the result of too few samples; however, it probably shows that the ice sheets advanced over essentially the same routes and thus incorporated the same materials.

Table 1. Pebble composition of till samples in the four to eight mm. size range.

composition / till samples	local rocks	granite	other ign. & meta.	ls. & dolo.
Cary	31%	17%	9%	43%
Tazewell (?)	21%	20%	11%	48%
Iowan (?)	15%	18%	9%	58%

Outwash

Cary outwash deposits are present in a channel between the Altamont and Bemis moraines and also in a channel running southwest from Punished Woman's Lake. The outwash deposits were derived from the Altamont moraine and are collapsed for a short distance southeast of South Shore. This collapse was caused by melting of blocks of ice deposited contemporaneously with the sand and gravel.

The composition of the sand and gravel varies locally but, in general ranges from 30 percent to 50 percent of soft carbonates and argillaceous rock, and the remainder is hard igneous and metamorphic rocks. The texture ranges from fine sand to very coarse gravels with 40 percent in the fine to very coarse sand range and 30 percent in the very fine gravel fraction. The gravels are locally oxidized in the upper four to five feet, and unleached throughout.

The thicknesses of the sands and gravels in the outwash were determined by drilling and resistivity measurements, and average about 51 feet. The thickness ranges up to a maximum of 75 feet in sec. 12, T. 118 N., R. 51 W.

Glacial Lake Deposits

Deposits from glacial lakes, as evident by strand lines, are present above the shores of some lakes and pot holes in the Cary drift of this area. The strand lines are usually two to five feet above the present lake levels, and in some cases are rimmed with boulders that were ice-rafted to their present positions. The areal distribution of most of the glacial lake deposits in the South Shore quadrangle is too limited to map. An unusually extensive deposit of this type is mappable, however around Punished Woman's Lake. Here, 60 feet of lake silts were penetrated, showing that the outwash channel which trends southwest from Punished Woman's Lake was dammed forming a large glacial lake.

Stream and Lake Deposits

Recent alluvium consists of silt and sand reworked from bedrock and older surficial deposits by present streams and lakes. The only alluvium in the South Shore quadrangle is confined to present lakes, as no large streams drain this area. The Recent lake-bed alluvium was not mapped, as it is covered by water during the wet seasons.

Wind Deposits

Loess is a wind deposit of silt, clay, and a few sand particles derived mainly from outwash plains. In the South Shore quadrangle, loess is scattered sporadically over the Cary drift up to 1½ feet thick, over the Tazewell (?) drift up to three feet thick, and somewhat more uniformly over the Iowan (?) drift, averaging about four feet thick. The loess is usually unleached where covered by a soil. The loess was not mapped because of its sporadic and normally thin occurrence.

SUBSURFACE SEDIMENTARY ROCKS

Sedimentary rocks are not exposed in the South Shore quadrangle, but at least 750 feet of Cretaceous rocks underlie the glacial drift, based on the following log of the Match #1 Drake oil test, located about a mile north of South Shore.

Log of samples from the Match #1 Drake Oil Test
Sec. 10, T. 119 N., R. 51 W.
Codington County, South Dakota
Altitude - 1899

Feet	Formation
0 - 540	Glacial Drift
540 - 750	Carlile (?)
750 - 780	Greenhorn (?)
780 - 1220	Graneros (?)
1220 - 1270	Dakota Group (?)
1270 - 1275 (T. D.)	No sample (Granite reported by drillers)

The above log may not be a true indication of the formations penetrated because of many discrepancies in the samples, coupled with disagreement on formation tops as reported by the drillers and promoters of the well.

PRECAMBRIAN ROCKS

The Cretaceous sedimentary rocks unconformably overlie the Precambrian basement rocks. In northeastern South Dakota the basement rocks are normally light-colored granite; however, in the U. S. Bureau of Reclamation well at Watertown (Erickson, 1955, p. 24), serpentine was penetrated below the Cretaceous rocks.

STRUCTURE

The structure of the bedrock in this area is very difficult to determine, as the bedrock is not exposed and well records are few. The regional dip was determined by using data from three previously mentioned deep wells (see Glacial Drift). It shows flat-lying beds and probably reflects the structural surface of the western extension of the Precambrian basement rocks.

ECONOMIC GEOLOGY

The most valuable geologic products in this area are ground water, and sand and gravel. Clay, silt, and hard rock could become economically important but at present are not used. Oil and gas possibly were trapped in the Cretaceous rocks where they pinch out against the Precambrian basement rocks.

Ground Water

Ground water adequate to supply ordinary farm wells is available throughout the quadrangle. Ground water in larger amounts may be found in the outwash channels or possibly in buried stream channels from former drainages. Ground water is also available from sand and gravel lenses in the till, but these are commonly small and are recharged very slowly; however, they generally contain enough water to supply domestic wells. Artesian water may be obtained in this area but would probably have to be pumped, as the piezometric head does not reach the height of the Coteau des Prairies in this area (Erickson, 1955, pl. 1).

The greatest potential area for ground water storage in the Still Lake quadrangle is in the sands and gravels of the Cary outwash channels. These channels contain an average of 51 feet of sand and gravel, and about 40 feet of water. The channels cover about 14,000 acres and contain about 560,000 acre-feet of water. This is enough water to support irrigation on most parts of the main outwash channel, if the reservoir has a normal amount of recharge. However, because the main outwash channel in the South Shore quadrangle is at a high altitude, it is not fed by any large streams and most of the small streams drain away from the channel rather than toward it. This means that most of this channel's recharge will come from direct precipitation on the channel surface, and this normally is not sufficient to support a large number of irrigation wells.

The water from the outwash is generally of good quality (table 2). However, the quality may vary greatly in short distances, as the chemical properties of the water are partly dependent on the composition of the sands and gravels through which the water flows.

Another possible source of water is the buried channels of former streams, which drained this area before the Cary glaciations and perhaps even before the Illinoian (Flint, 1955, p. 142). The locations of the valleys of these former streams (fig. 2) can be inferred from linear topographic lows, and may contain deposits of sand and gravel filled with water. If the amount of water in these buried channels is great enough, and the physical conditions are suitable, the channels may provide an additional source of water for irrigation.

Table 2. Water analysis* of shallow well in South Shore quadrangle.

contents ppm / source	Ca	Mg	Na	K	SO_4	N	Cl	Fe	SiO_2	$CaCO_3$ (bicarbonate)	$CaCO_3$ (carbonate)	Hardness ($CaCO_3$)
Public Health Standard**	-	125	-	-	250	10	250	0.1	10	-	-	-
Outwash***	46	15	3	2	18	1	5	0	24	140	0	10.2

* Analyst: Dr. O. E. Olson, Head, Dept. of Biochemistry, South Dakota State College, Brookings, South Dakota, 1957.
** Not to exceed.
*** J. B. Janssen farm, sec. 34, T. 120 N., R. 50 W.

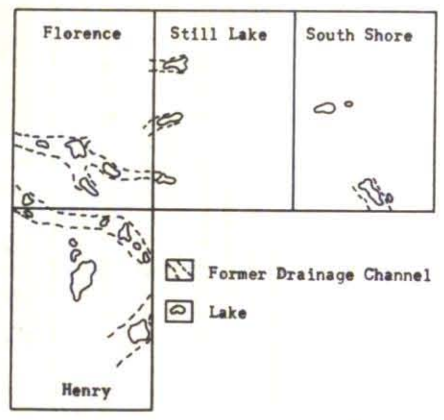


Fig. 2. Map of South Shore and adjacent quadrangles showing inferred former drainage channels (modified from Flint, 1955, pl. 7).

Sand and Gravel

The outwash channels cover about 22 square miles and contain about 1,100,000,000 cubic yards of sand and gravel. The gravels are suitable for road building and possibly for bituminous or concrete aggregate, if the high percentage of soft materials is removed.

Clay and Silt

The till and loess of this area contain a large amount of clay and silt, which could possibly be used in the manufacture of brick and tile.

Rock

Glacial boulders scattered on the surface could provide a source of hard rock. The largest concentrations of the boulders occur on the Cary end moraine. About 75 percent of the boulders are granitic, and should be suitable for rip-rap, structural material and, if crushed, as concrete aggregate.

REFERENCES CITED

Bolin, E. J., and Petsch, B. C., 1954, Well Logs east of the Missouri River: S. Dak. Geol. Survey, Rept. Invest. 75, 95 p.
Carman, J. E., 1915, The Pleistocene geology of northwestern Iowa: Iowa Geol. Survey, Annual Rept. 26, p. 233-445.
Chamberlin, T. C., 1883, Terminal moraine of the second glacial epoch: U. S. Geol. Survey, third Annual Rept., p. 291-402.
Erickson, H. D., 1955, Artesian conditions in northeastern South Dakota: S. Dak. Geol. Survey, Rept. Invest. 77, 39 p.
Fenneman, N. M., 1938, Physiography of Eastern United States: McGraw-Hill Book Company, Inc., New York.
Flint, R. F., 1955, Pleistocene geology of eastern South Dakota: U. S. Geol. Survey, Prof. Paper 262, 173 p.
Leighton, M. M., 1933, The naming of subdivisions of the Wisconsin Glacial Age: Science, N. S. 77, p. 168.
Leverett, Frank, 1932, Quaternary geology of Minnesota and parts of adjacent States: U. S. Geol. Survey Prof. Paper 161, 149 p.
Rothrock, E. P., 1943, A Geology of South Dakota: S. Dak. Geol. Survey, Bull. 13, pt. 1, map.
Steece, F. V., Tipton, M. J., and Agnew, A. F., (In Preparation), Revised glacial geology, Coteau des Prairies, South Dakota: S. Dak. Geol. Survey, Bull.